

**REMARKS**

Claims 5, 7, 9 and 11 are pending in this application. By the Office Action, the disclosure is object to and claims 5-12 are rejected under 35 U.S.C. §103(a). By this Amendment, claim 5 is amended to incorporate the limitations of claim 6; claims 6, 8, 10, and 12 are cancelled; and the specification is amended. No new matter is added.

The disclosure is objected to as lacking a cross-reference to the prior application. The specification is amended herein to include the cross-reference. Reconsideration and withdrawal of the objection are respectfully requested.

Claims 5-12 are rejected under 35 U.S.C. §103(a) as being unpatentable over Ito (U.S. Patent No. 6,086,670) in view of Iizuka (U.S. Patent Application Publication 2004/0072437). Applicant respectfully traverses the rejection.

Amended claim 5 recites a method for producing a silicon wafer having a crystal orientation  $\langle 110 \rangle$  from a silicon single crystal ingot grown by Floating Zone method (FZ method), wherein, at least, an FZ silicon single crystal ingot is grown by being made to be dislocation-free by Dash Necking method using a seed crystal having its crystal axis inclined at a specified angle from a crystal orientation  $\langle 110 \rangle$ , and the grown FZ silicon single crystal ingot is sliced at the just angle of a crystal orientation  $\langle 110 \rangle$  to produce a silicon wafer having a crystal orientation  $\langle 110 \rangle$ , and the sliced silicon wafer having a crystal orientation  $\langle 110 \rangle$  is made to be a perfect circle by processing of chamfering. Such a method is not taught or suggested by the cited references.

The Office Action admits that Ito does not disclose a silicon wafer with a  $\langle 110 \rangle$  crystal orientation, but asserts that Iizuka teaches a Floating Zone method for producing a silicon wafer having a  $\langle 110 \rangle$  crystal orientation. Applicant respectfully submits that Iizuka does not teach a Floating Zone method for producing a silicon wafer having a  $\langle 110 \rangle$  crystal orientation. This is shown in Iizuka at paragraph 28, where the scope of the crystal orientation

disclosed is defined: "as to the plain orientation (100) according to the present invention, not only the wafer of which plain orientation is exactly (100) but also the wafer of which plain orientation is inclined up to about 4° from (100) are included." Therefore, by explicitly defining the included orientations, Iizuka has disclaimed any other crystal orientations such as  $\langle 110 \rangle$ . That Iizuka does not teach a crystal orientation of  $\langle 110 \rangle$  can further be seen from the examples. The crystal orientation taught in each of the examples of Iizuka (where crystal orientation is mentioned) is  $\langle 100 \rangle$  (Paragraphs 142, 152) in accordance with the above explicit scope of the orientations encompassed by Iizuka.

Of course, Iizuka does show etch pits forming square-shaped openings with four sides along a crystal orientation  $\langle 110 \rangle$  (Paragraph 29). However, the orientation of the *pits* is entirely different from the crystal orientation of the *wafer* itself. This can be seen in Figs. 2(a)-(f), and is described in Paragraph 124. In this way, Iizuka teaches a silicon wafer having a crystal orientation of  $\langle 100 \rangle$ , while only the four sides of the square-shaped etch pits in the etched surface of the silicon wafer open with a crystal orientation of  $\langle 110 \rangle$ , not the wafer itself.

Furthermore, there is no teaching, suggestion or motivation in any of the cited references, taken separately or together, to lead a person of ordinary skill in the art to combine the teaches of Iizuka with the teachings of Ito, and then to modify the combination to practice the claimed invention.

An object of the claimed invention is to produce a silicon wafer having a crystal orientation  $\langle 110 \rangle$  from a silicon single crystal ingot made to be dislocation-free. On the other hand, the object of Iizuka is, as cited by Examiner, to prevent degradation of surface roughness of a wafer. Since the claimed invention does not concern surface roughness, a person of ordinary skill would not have been motivated to modify the teachings of Iizuka to

produce a silicon wafer having a crystal orientation  $\langle 110 \rangle$  from a silicon single crystal ingot made to be dislocation-free.

Additionally, the object of Ito is to provide a uniform resistivity distribution on the surface of an n-type silicon wafer having a  $\langle 111 \rangle$  orientation (column 2, line 13). The objects of Ito and Iizuka are thereby completely different not only from each other, but also from the object of the claimed invention. In this way, a person of ordinary skill in the art would not have been motivated to modify the teachings of Ito with those of Iizuka in order to practice the claimed invention. Therefore, the combination of references improperly relies upon Applicant's claims as a roadmap to piece together the claimed components into a single composition.

Moreover, the claimed invention was found to have unexpected results of drastically improving yield and productivity of silicon wafers having a crystal orientation  $\langle 110 \rangle$  suitable for fabricating high-speed semiconductor devices (see for example page 11, lines 8-13; page 12, line 21 through page 13, line 17). Specifically, if a seed crystal having its crystal axis inclined at a specified angle from a crystal orientation  $\langle 110 \rangle$  is used, the direction of the single crystal growth is also inclined at a specified angle from a crystal orientation  $\langle 110 \rangle$ . Therefore, the propagation direction of slip dislocations introduced at high density by thermal shock when the seed crystal is fused can be different from the direction of the single crystal growth. Accordingly, the dislocations can be led outward to the direction of the single crystal growth and made to disappear in the neck portion by Dash Necking, and a FZ silicon single crystal ingot made to be dislocation free can thereby be grown at a high success rate. Then, if the grown FZ silicon single crystal ingot is sliced precisely at the above mentioned specified angle, a silicon wafer having a crystal orientation  $\langle 110 \rangle$  can easily be produced. After which the sliced silicon wafer is made to be a perfect circle by the process of chamfering, thereby producing with unexpected ease and yield a silicon wafer having a crystal orientation  $\langle 110 \rangle$ .

which can be used for semiconductor devices. These unexpected results are not taught or suggested by the cited references, and further indicate that a person of ordinary skill would not have been motivated to combine the teachings of Iizuka with the teachings of Ito to practice the claimed invention.

For at least these reasons, one of ordinary skill in the art would not have been motivated to combine the references in the manner asserted in the Office Action.

Finally, there is no description in either Ito or Iizuka of a silicon wafer having a crystal orientation  $\langle 110 \rangle$  and making the sliced silicon wafer to be a perfect circle through the processing of chamfering. Therefore, even if Ito and Iizuka are combined with each other, they could not have rendered obvious the claimed invention. Claims 5, 7, 9 and 11 are thus patentable over the cited references.

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 5, 7, 9 and 11 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



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